(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 181 134**
A2

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 85307767.5

(22) Date of filing: 28.10.85

(51) Int. Cl.⁴: H 01 M 8/06
H 01 M 8/04

(30) Priority: 29.10.84 US 665488
21.10.85 US 788141

(43) Date of publication of application:
14.05.86 Bulletin 86/20

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

(71) Applicant: ENGELHARD CORPORATION
70 Wood Avenue South CN 770
Iselin New Jersey 08830(US)

(72) Inventor: Feigenbaum, Haim
10 Rachavat Ilan
Ramat Ilan(IL)

(72) Inventor: Kaufman, Arthur
69 Burnett Terrace
West Orange New Jersey(US)

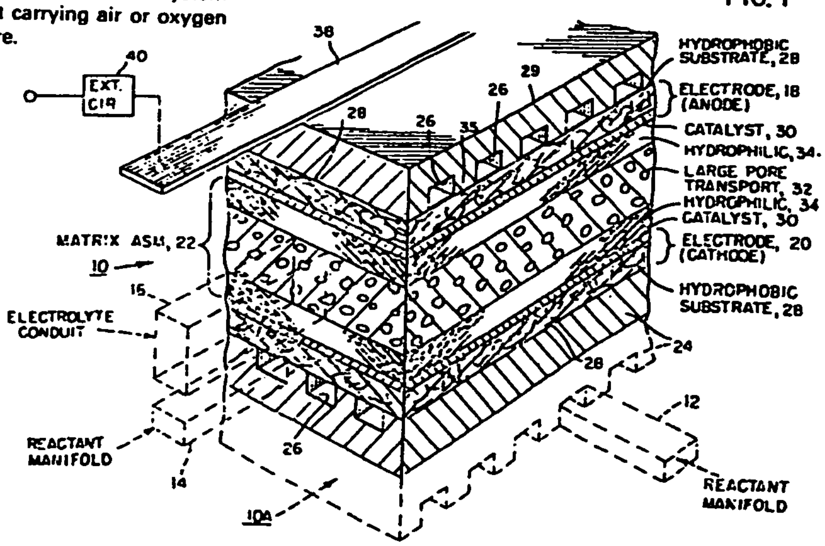
(72) Inventor: Singh, Rajindar
39 Corsa Terrace
Ridgewood New Jersey(US)

(74) Representative: Fisher, Adrian John et al,
Carpmaels & Ransford 43 Bloomsbury Square
London WC1A 2RA(GB)

(54) **Fuel cell system having electrolyte reclaiming means.**

(57) An electrolyte reclamation system for use in a fuel cell having means for removing electrolyte and collecting it from reactants after they have exited the fuel cell. The system simultaneously purifies the reactant carrying air or oxygen before it is vented to the atmosphere.

FIG. I



Croydon Printing Company Ltd.

FUEL CELL SYSTEM HAVING ELECTROLYTE RECLAIMING MEANS

BACKGROUND OF THE INVENTION

The invention relates to fuel cells and, more particularly, to reclaiming and reducing electrolyte from reactants.

Reference is hereby made to other related patents and patent applications which are assigned to the same assignee as the present application; application of H. Feigenbaum entitled "Fuel Cell With Electrolyte Feed System," Serial No. 430,156,* filed September 30, 1982; Application of O. Adlhart entitled "Fuel Cell With Multiple Porosity Electrolyte Matrix Assembly," Serial No. 430,143,* filed on September 30, 1982; U.S. Patent 4,463,066 of O. Adlhart et al; U.S. Patent 4,463,067 of H. Feigenbaum; and U.S. Patent 4,463,068 of Cohn, et al.

Much research is being done in the area of fuel cell technology in order to provide ever increasing amounts of electric power and for operating such cells over longer periods of time without any need for shutdown to accomplish maintenance. As compared to other methods of generation of electric power from combustible fuels, a fuel cell has higher efficiency and is also characterized by a simplicity of physical structure in that such cells can be constructed without any or relatively few moving parts.

While a variety of electrochemical reactions are known for the conversion of fuel into electricity without the direct burning of such fuels, one well known form of cell utilizes the reaction between air or oxygen and hydrogen, the hydrogen serving as the fuel. One common form of construction for the hydrogen-air/oxygen cell is the laminated structure wherein the electrodes are spaced

* see EP-A-0106605

apart by a porous layer of material which holds an electrolyte. For example, the electrolyte may be a concentrated phosphoric acid. The hydrogen is guided by passageways behind the active region of the anode, and the air or oxygen is guided by passageways behind the active region of the cathode. At the anode, the hydrogen gas dissociates into hydrogen ions plus electrons in the presence of a catalyst, typically a precious metal such as platinum or platinum with other metals. The hydrogen ions migrate through the electrolyte to the cathode in a process constituting ionic current transport while the electron travels through an external circuit to the cathode. In the presence of a catalyst at the cathode, the hydrogen ions, the electrons, and molecules of air or oxygen combine to produce water.

In order to provide for the physical placement of the respective reactants at catalyst layers of the anode and cathode, layers of materials having hydrophilic and hydrophobic properties are disposed in an arrangement contiguous to the catalyst layers. They permit the electrolyte and the air or oxygen at the cathode and the hydrogen at the anode to contact the catalyst layer. The hydrophobic material is provided with pores of sufficiently large size to permit the gaseous hydrogen and the gaseous air or oxygen to freely flow through the material so as to come into contact with the catalyst.

Details in the construction of fuel cells, and in the components parts thereof, are disclosed in the United States Patents 3,453,149 of Adlhart and 4,064,322 of Bushnell. These two patents show structures for guiding the gaseous reactants into the regions of the catalyst. In addition, the Bushnell patent shows space within a cell for the storage of electrolyte so as to compensate for any changes in the quantity of electrolyte available for ion transport. An assembly for combining together a plurality of fuel cells in a single power source is

disclosed in U.S. Patent 4,175,165 of Adlhart. This patent also shows manifolds for the simultaneous feeding of the reactant gases to the cathode and the anode of the respective cells.

To provide increased amounts of electric power and operation over longer periods of time, fuel cells are often assembled as a plurality. A common type of fuel cell assembly is the fuel cell stack. The fuel cell stack allows the cells to be assembled in a convenient and compact manner for various different applications. Fuel cells and stacks in particular are usually contained in a protective container which help to provide support for the assembly and more significantly to define entrances for fuel cell reactants.

Separate reactant entrances and exits are provided for each reactant, especially when the fuel cells are in a stacked configuration. The assembly of the stack and container is such that the reactants are maintained separate and distinct from one another. The means for supplying the reactants to the fuel cells can include a simple device such as a fan or the like. Thus, the reactants are introduced into their respective passageways uncontaminated by any other reactant.

In the operation of a conventional fuel cell, the electrochemical reaction takes place after the reactants travel through their respective passageways within the fuel cell to catalyst areas of the electrodes. The electrodes, anode and cathode are maintained in a spaced relationship to one another, the space being at least partially filled by electrolyte. The electrolyte, of course, provides a means of ionic transport between the electrodes and is usually held in a matrix material. In addition, electrolyte held in a storage system may be used to replenish the electrolyte in the matrix of each cell as required.

One method of solving the problem of electrolyte loss in the matrix has been the method of storing additional electrolyte in a reservoir and distributing this stored electrolyte to the matrix when the electrolyte needs to be replenished. Such storage and feed means are disclosed in aforementioned patents and patent applications: U.S. Patent 4,463,066, U.S. Patent 4,463,068, U.S. Patent 4,463,067 and Patent Application Serial No. 430,156.

A problem arises when a cell in the stack experiences a loss of electrolyte from within the matrix. These losses, for instance, are usually the result of electrolyte volume changes, such as those due to temperature and composition changes, resulting in electrolyte evaporation. The electrolyte vapor or droplets from the cell tend to migrate into the passageways behind the electrodes. An electrolyte mist then forms in the passageways when the vapor or droplets mix with the reactant. This electrolyte mist is carried with the reactants as they flow out of the cell and, in case of air or oxygen reactants, when the air or oxygen exits to the atmosphere from the stack. Thus, the exiting reactants are contaminated by the electrolyte mist as the reactants exit the system.

A further problem arises with the loss of electrolyte. Depending on the amount of storage capacity of a cell or in an electrolyte storage system that supplies additional electrolyte to each cell as required, the fuel cells can only be operated for a limited length of time before there is not enough electrolyte for proper operation. In this case, the system must be shut down for maintenance; that is, the replenishment of the lost electrolyte in the requisite concentration, or the cell or stack may burn out. However, supplying additionally stored electrolyte from a fixed capacity storage system to the matrix does not solve the problem of wasteful loss

of electrolyte indefinitely or of effluents being placed in the air or oxygen surrounding the fuel cell stack.

Prior systems have been designed to contain electrolyte on the proper side of the electrode. For instance, one method of collecting electrolyte that has undesirably penetrated into the gas side of the electrode is disclosed in U.S. Patent 3,708,341 of Biddick. This patent discloses a means to collect and return the electrolyte after it has formed into droplets on the gas side surface of the electrode. However, Biddick appears to only describe a means to return electrolyte to the matrix before it escapes from the fuel cell. In addition, Biddick does not appear to address the problem of reclaiming electrolyte vapor, nor does Biddick solve the problem of reclaiming the electrolyte once it has been lost from the fuel cell.

Another system for reclaiming electrolyte is disclosed in U.S. Patent 4,414,291 to Breault which describes a construction for internally condensing evaporated electrolyte before it leaves the fuel cell. The condensed electrolyte is taken up by the cell electrode and redistributed throughout the cell by diffusion and capillary action. Another disclosure, U.S. Patent 3,861,958 to Cheron discloses a complex system of pumps, valves, cooling devices and the like for recovering liquid electrolyte leaks in a fuel cell.

Advantages of the present invention include the provision of a system wherein electrolyte in the form of a mist contained in the exiting reactant gases may be separated from the reactants before they are discharged. The electrolyte mist is collected from the reactant gas at an efficient rate and can be reclaimed for redistribution to the fuel cells or for storage either internally or externally of the system. The invention also provides for the removal of an electrolyte effluent

from the reactant gases before they discharge into the atmosphere.

SUMMARY OF THE INVENTION

The foregoing problems are overcome and other advantages are provided by a fuel cell with a system for reclaiming vaporized or misted electrolyte thereto. The reclaimed electrolyte may be transported back into the fuel cell system or externally thereof.

In one embodiment, the fuel cell is constructed with an electrolyte supporting structure having a means to draw and distribute electrolyte therein, and the reclamation system is constructed so as to return electrolyte mist carried out of the fuel cell to the electrolyte distribution system for availability to the cell by a reactant.

In accordance with an embodiment of the invention, reactant exiting from the fuel cell containing the electrolyte mist is circulated to an electrolyte collecting unit. The reactant passes through a carbon fiber sponge such that the electrolyte is collected by this sponge. The sponge is in direct contact with a carbon fiber wick which is connected to the electrolyte distribution and storage system. As the amount of electrolyte in the carbon fiber sponge increases, a wicking process takes place in which the excess electrolyte is transported via the carbon fiber wick back to the electrolyte distribution and storage system.

In another embodiment, the fuel cell is constructed with an electrolyte supporting structure having a means to draw and distribute electrolyte therein with the reclamation system constructed so as to return the electrolyte to an electrolyte storage system for eventual use with an electrolyte distribution system.

In yet another embodiment, the reclamation system is constructed to transport the collected electrolyte externally of the system.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and other features of the invention are explained in the following description taken in connection with the accompanying drawings wherein:

Figure 1 is a perspective sectioned view of a portion of a fuel cell stack showing one complete fuel cell with an electrolyte replenishment conduit;

Figure 2 is a diagrammatic view of a system for supplying electrolyte to a cell stack and reclaiming electrolyte mist from the air or oxygen reactant and returning the electrolyte to the supplying system;

Figure 3 is an enlarged, more detailed, diagrammatic view of the electrolyte collecting unit as shown in Figure 2;

Figure 4 is a diagrammatic view of an alternate embodiment of the invention wherein the reclaimed electrolyte is returned to the electrolyte reservoir of the fuel cell stack; and

Figure 5 is a diagrammatic view of a system of another alternate embodiment of the invention wherein the collected electrolyte is stored externally of the fuel cell system.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows a fuel cell 10 in perspective view. While the following description of the fuel cell 10 is in detail, it will be apparent that the invention may be utilized with any type of fuel cell known in the art. For instance, as depicted herein, the system used may be one wherein reclaimed electrolyte may be fed into the fuel cell to replenish depleted electrolyte. However, the invention is not limited to this type of fuel cell system.

As shown in Figure 1, a part of a second fuel cell 10A, having the same construction as the cell 10, is shown in phantom placed contiguous to the cell 10. The

cell 10 is thus understood to be one of many such cells which would ordinarily be placed in a stack as shown in Figure 2. Connections of the cells 10 and 10A via manifolds for the conveyance of reactants and via conduits for the conveyance of electrolyte are shown schematically. Two such representative manifolds are shown: a manifold 12 for the conveyance of hydrogen to the anode or respective cells of the stack and a manifold 14 for the conveyance of air or oxygen to the cathode or respective cells of the stack. A set of electrolyte conduits 16 (only one of which is shown) conveys electrolyte to the respective cells of the stack. Although manifolds 12 and 14 are shown in a representative fashion in Figure 1, it is understood that a single manifold for each reactant running generally along the side of the stack can feed reactants to the cells through respective passages 26.

The fuel cell 10 comprises two electrodes, namely, an anode 18 and a cathode 20 which are separated by a means to draw and distribute electrolyte such as an electrolyte matrix assembly 22, Each electrode abuts a reactant distribution plate 24. The top of the cell in Figure 1, having grooves to bring in and distribute only one reactant since it is at the end of the stack, has a termination plate 24. The plates 24 on the other side of the cell depicted are part of a bi-polar assembly made up of two gas distribution plates 24 in back-to-back position to supply reactants to the cell shown and the adjacent cell not shown. Plates 24, both the termination plate, and the bi-polar assembly, have passages 26 for the entry of the fluidic or gaseous reactants and discharge of any residual gases. Each electrode comprises a hydrophobic substrate layer 28 and a catalyst 30. The respective plates 24 of the cells 10 and 10A provide a serious interconnection of the two cells. The means to draw and distribute electrolyte in the cell can

be of any suitable type. For instance, it can be a material having pores therein of a particular size to draw and distribute the electrolyte. Alternatively, it can be a material made from two or more layers of different size pores, such as that shown in Figure 1.

The matrix assembly 22 comprises a central permeable layer 32 of fibrous carbon sheet material having relatively large pores, the central layer 32 being positioned between two outside permeable layers 34 with pores which are smaller than the pores of the central layer 32. The electrolyte, typically phosphoric acid, is contained in the central layer 32. The pores of the central layer 32 are sufficiently large to permit the electrolyte to freely migrate through the central layer 32 so as to replenish the electrolyte within the cell 10 as may be required. The central layer 32 need not necessarily be completely filled with the electrolyte, it being necessary only to provide sufficient electrolyte to insure ionic conductivity between the electrodes 18 and 20.

The smaller pores of the outside hydrophilic layers 34 exert a strong capillary force which draws in the electrolyte from the central layer 32 to completely fill each of the outside layers 34. Layers 34 have a fast rate of uptake of electrolyte contained in the large pore layer 32 as needed. By providing adequate electrolyte to layers 34, each outside layer 34 serves as a barrier against the flow of reactant gas into the matrix assembly area. Thus, electrolyte is found in each of the three layers of the matrix assembly 22 to provide ionic conductivity therein; that is, the electrolyte therein serves as a path by which positive hydrogen ions can migrate via ionic current transport from the anode 18 to the cathode 20.

The hydrophobic layers 28 are impregnated with PTFE on the base material of the fibrous carbon to produce the

hydrophobic characteristics. The hydrophobic layer 28 is characterized by large pores through which the gaseous reactants can freely circulate so as to propagate from the passages 26 to the catalyst 30. Thus, the catalyst 30 is surrounded by hydrophobic and hydrophilic layers, the hydrophobic layer facing the gaseous reactants and the hydrophilic layer facing the electrolyte.

The hydrophobic layer 28 in each electrode is impregnated with PTFE particles to prevent the electrolyte from flooding into the electrode. This is an advantageous feature in the construction of the cell 10 since such flooding, if permitted, would reduce the number of open pores through which the gaseous reactants must pass in the electrodes. A reduced number of available pores would result in a diminution in the capacity of the cell to produce electricity.

The hydrophobic layer 28 brings the gaseous reactant into contact with the catalyst 30 while the hydrophilic layer 34 brings the electrolyte into contact with the catalyst 30. Thereby, respective electrochemical reactions can take place at the catalyst 30 of the anode 18 and at the catalyst 30 of the electrode 20. The catalyst 30 is conveniently formed of a precious metal such as platinum with or without other metals which, for the purpose of bonding and wet-proofing, is deposited on the hydrophobic layer 28. The same construction is utilized in each of the electrodes 18 and 20.

It is noted that both the hydrophobic layer 28, the plate 24 and the electrodes 18 and 20 are electrically conducting. Thus, in the case of the anode 18, electrons released by the electrochemical reactions can propagate from the catalyst 30 through the carbon mat of the hydrophobic layer 28 and into the partitions or ribs 36 of the plate 24 which separate the respective passages 26.

In the series arrangement depicted in Figure 1, the electrons from the anode of one cell are conducted directly to the cathode of the adjoining cell so as to migrate through the entire stack. An exemplary stack termination contact 38 is shown attached by conventional methods to the plate 24 of the anode 18. The contact 38 is coupled to an external circuit 40 (indicated in block diagrammatic form) while the other terminal of the external circuit 40 is coupled to a similar contact (not shown) at the opposite end of the stack of the fuel cells. The electrons can, thereby, make a complete circuit from the negative terminal of the stack (the last of the anodes) via the external circuit 40 to the positive terminal of the stack (the first of the cathodes). Correspondingly, the hydrogen ions can migrate in each cell through the electrolyte contained in the matrix assembly proceeding from the anode of the cell through the electrolyte to the cathode.

As shown in Figure 2, fuel cells 10 are stacked to form a fuel cell stack 11. Surrounding the fuel cell stack 11 is a protective container or stack housing 53. The protective container 53 can be of any type known in the art whereby the fuel cell stack 11 is protected from possible damage by external sources and also provides a means to contain any inadvertent leakage of the liquid electrolyte.

The container 53 is preferably sealingly engaged (to the atmosphere) with the fuel cell stack 11 and has inlets and outlets for the reactant gas. Air containing the reactant oxygen is admitted into the container 53 through a reactant inlet 54. A similar inlet (not shown) is provided for the other reactant. A means to introduce the reactant (not shown) may be of any type known to the art, such as a fan. The reactant gas inlet 54 communicates with an inlet chamber 51 which allows the air or oxygen to access the entrances to the reactant

manifolds 14 (see Figure 1) of each of the cells 10 in the stack 11. The configuration of the fuel cell stack 11 sealingly engaged with the container 53 defines the path of the air or oxygen through the fuel cells 10. The other reactant is passed in and out of the cells via its own inlets and outlets and kept separate from the air or oxygen in the stack in this manner.

The opposite ends of the reactant manifolds 14, communicate with an outlet chamber 55. The outlet chamber 55 communicates with a reactant gas outlet 57 whereby the air or oxygen can exit the protective container 53. A similar outlet (not shown) also is provided for the other reactant.

The embodiment of the invention as shown in Figure 2 has an electrolyte replenishment system 42. The electrolyte replenishment system 42 may be of any type known to the art, and preferably, the system is capable of supplying electrolyte to the fuel cells 10 when necessary.

As shown in the embodiment of Figure 2, and for illustrative purposes only, the replenishment system 42 comprises an electrolyte distribution column 44. The column 44 is connected to the fuel cells 10 via electrolyte conduits 16 containing wicking carbon fibers 13. The wicking carbon fibers are relatively dense, rope-like material which is saturated with the electrolyte and aids in transporting the electrolyte by means of capillary action. The replenishing electrolyte is stored in an electrolyte reservoir 46 whereby a pump 50 may pump the electrolyte via piping 52 to the top of the electrolyte distribution column 44. Excess electrolyte within the distribution column 44 that is not used by the fuel cells 10 may be transported back to the reservoir 46 via piping 48 located at the bottom of the distribution column 44.

The reactant outlet 57 (in this case, an air or oxygen outlet) is connected to a reactant conduit 56. The reactant conduit 56 connects the container 53 to an electrolyte reclaiming unit 58. The air or oxygen propelled by a fan or like means (not shown) enters the container 53 through the reactant manifolds 14 of the fuel cells. In the course of operation of the fuel cells, not all of the electrolyte remains within the matrix assembly 22, but some quantity thereof finds its way eventually into the passages 26 where it is suspended in the form of a vapor or droplets. As the air or oxygen flows through the passages 26 of a cell from the inlet chamber 51 to the outlet chamber 55, and beyond, it assimilates the electrolyte vapor or droplets to thereby create mixture composed of air or oxygen and of an electrolyte mist, that is, particles of electrolyte of sub-micron size. This mixture of air or oxygen and electrolyte vapor or mist is forced out of the container 53 at outlet 57 by newly entering air or oxygen at the inlet 54. The mixture of air or oxygen and electrolyte material then travels through the conduit 56 to the reclaiming unit 58. Though the system for transporting the reactant and electrolyte mist has been described in detail, any suitable material or configuration could be used to accomplish the system's preferred function.

Figure 3 shows an enlarged view of the electrolyte reclaiming unit 58 having a housing 64. This embodiment utilizes a plurality of reactant conduits 56 which communicate with the housing 64 at inlets 60 and extend from the outlets 57 at the container 53. Preferably, a flow diffuser 62 is located at each inlet 60 and is provided to insure proper distribution of the air or oxygen and electrolyte mist mixture throughout the housing 64. This diffusion occurs simultaneously with the substantial reduction in velocity of the incoming mixture. Such velocity reduction enhances the diffusion

process and occurs by reason of the large volume ratio existing between the housing 64 and the conduits 56. Sealingly engaged with the housing 64 is a cover 66. Although the housing 64 may be constructed as a unitary member, the cover 66 also may be constructed so as to be detachable from the housing 64 to provide access to the interior of the reclaiming unit 58 for maintenance, repair, or systematic checking.

Located within the housing 64 is a carbon fiber sponge 70 as best seen in Figure 3. Throughout this specification, the term "sponge" is to be understood to mean a very porous, pliable, fibrous structure through which a gas stream may be passed without significant pressure drop. A construction of the sponge 70 suitable for purposes of the invention is activated carbon cloth, Type KFN-1500-150 sold by Toyobo Company, Ltd. of Osaka, Japan. Among its characteristics are the following:

weight -	150 g/m^2
bulk density -	0.20 g/cm^3
air permeability -	7100 cm^3 of air/cm^2/min. at a pressure drop of 12.5 mm water
BET surface area -	1450 +/- 50 m^2/g

The top of the sponge 70 is attached to the cover 66, and located at the opposite end of the sponge 70 is a base plate 74. Preferably, the sponge 70 is sealingly engaged to both the cover 66 and the base plate 74. As illustrated, the fiber sponge 70 is cylindrical in shape and encompasses a hollow core or chamber 76. This chamber 76 communicates with an exit 68 located in the cover 66 for venting the purified air or oxygen to the atmosphere. While this form of construction is preferred, numerous other shapes and designs can be employed for purposes of the invention.

As the air or oxygen carrying the electrolyte mist enters the housing 64, as shown by directional arrows A, it passes through the flow diffusers 62 and enters the interior of the housing 64 as shown by directional arrows B. The mixture of air or oxygen and electrolyte mist which is uniformly distributed throughout the interior of the housing is then forced into the carbon fiber sponge 70 by newly entering air or oxygen and mist as shown by directional arrows C. The sealing engagements between the base plate 74 and the sponge 70 and between the cover 66 and the sponge 70 prevent the mixture from exiting the reclaiming unit 58 without first traveling through the carbon fiber sponge 70.

The generally cylindrical construction of the carbon fiber sponge 70 as illustrated in Figure 3 allows the air or oxygen to pass through the sponge 70 into the interior chamber 76 where it may exit the housing 64 at the exit 68 in the cover 66. As the electrolyte mist is carried into the sponge 70 with the air or oxygen, the electrolyte material is deposited on the fibers of the fiber sponge 70. At the same time that the sponge is sufficiently dense to remove the electrolyte unit from the air, it is sufficiently porous to allow free passage of the cleansed air therethrough. In time, the mist particles coalesce to form droplets.

The coalescing process generally is a characteristic of the carbon fiber sponge 70 whereby the velocity of the small particles of electrolyte material is reduced to a point where newly entering mist unites with the slower moving electrolyte particles. This forms ever larger particles thereby increasing their resistance to be carried by the flowing air or oxygen and increasing the surface area for removing and collecting more electrolyte. These particles then descend to the base of the fiber sponge. Although the means for removing and collecting the electrolyte mist from the reactant gas has

been generally described as a carbon fiber sponge 70, it is obvious that the system for reclaiming the electrolyte could be used with any other suitable material or configuration of the material to functionally accomplish the removal and collecting of the electrolyte from the reactant gas.

Located at the bottom of the carbon fiber sponge 70 are carbon wicks 72. As with the wicking carbon fibers 13, the wicks 72 are relatively dense, rope-like material composed of carbon or other suitable material. The wicks 72 are in direct contact with the sponge 70 and pass through apertures 80 in the base plate 74 and apertures 78 in the housing 64. Preferably, the wicks 72 are sealingly engaged with both apertures 78 and 80 to prevent the air or oxygen and electrolyte mist from exiting the housing before passing through the sponge 70.

The carbon wicks 72 may be of any conventional design whereby the collected electrolyte material may enter the wicks 72 at the carbon fiber sponge 70 and flow through the wicks 72 to its opposite end where the electrolyte may exit. Preferably, the sides of the wicks 72 are coated with a suitable coating to prevent the electrolyte from escaping before it reaches the wick's exit end. However, it should be apparent to one skilled in the art that any suitable means or material to transport the collected electrolyte may be used with the system.

In one embodiment of the invention, as shown in Figure 2, the wicks 72 transport the collected electrolyte from the carbon fiber sponge 70 to the top of the electrolyte distribution column 44 of the replenishment system 42. Generally, the transport of the collected electrolyte is controlled by capillary forces and by gravity causing the electrolyte in the wicks 72 to travel in a downward direction.

In operation, air or oxygen is introduced into the fuel cell stack 11 at the reactant inlet 54. The air or oxygen then enters the open ends of the manifold 14 into the passages 26 of the cathodes 20 in each of the cells of the stack. Hydrogen is admitted into the manifold 12 to the passages 26 in the anodes 18 of each of the cells in the stack. Electrolyte is applied via the set of conduits 16 to make contact with the central layers 34 of the membranes 22 in the respective fuel cells of the stack.

By capillary action, the electrolyte is brought into contact with the catalyst 30 in each of the electrodes 18 or 20. The hydrogen propagates from the passages 26 through the pores of the hydrophobic layer 28 to the catalyst 30 in the anode 18. Thereby, the hydrogen and the electrolyte are placed in contact with each other at the interface of the catalyst 30 at the anode 18, and the air or oxygen and the electrolyte are placed in contact with each other at the interface of the catalyst 30 of the cathode 20 to provide for the respective electrochemical reactions at the anode 18 and cathode 20. It is in these locations of the cell that the respective electrochemical reactions to produce ion flow across the electrolyte and, therefore, electricity occurs.

Further details on the construction of the respective layers of the cell 10 are well known, and are described, by way of example, in the foregoing U.S. Patents 3,453,149; 4,064,322 and 4,175,165. These patents describe the construction of cells utilizing porous material with PTFE and coatings of precious metal catalysts. The multiple porosity characteristic of the matrix assembly 22 provides for both the hydrophilic properties of the other layers 34 while utilizing the larger pores of the central layer 32 for holding, moving and distributing the electrolyte so as to maintain the electrolytic saturation of the outer layers 34 during

operation of the cell 10. In addition, the presence of the electrolyte in all three layers of the matrix assembly 22 provides the requisite conduction path for the hydrogen ions. Thus, the matrix assembly 22 of the invention permits the cell 10 to operate normally while maintaining the uniform distribution and the proper level of electrolyte therein.

The matrix assembly 22 of each cell is continuously in contact with a quantity of electrolyte held outside the cell and brought in by the set of conduits 16 from an external reservoir 46 of such electrolyte as shown in Figure 2. This insures that the cell 10 is always filled with the requisite amount of electrolyte until the reservoir 46 is depleted.

As reactant gases flow through the cells, some of the electrolyte is transformed into vapor. This electrolyte vapor penetrates into the passages 26 thereby mixing with the air or oxygen to form an electrolyte mist. As new air or oxygen is introduced into the fuel cell stack 11 at the reactant gas inlet 54, the residual air or oxygen and electrolyte mist are pushed through and exit the fuel cells 10 into the outlet chambers 55. As air or oxygen is continually introduced through the reactant gas inlet 54 and the air or oxygen and electrolyte mist mixture enters the chamber 55, the mixture in the chamber 55 is forced into the reactant conduit 56.

The mixture in the conduit 56 is correspondingly pushed through the conduit 56 towards the electrolyte collecting unit 58. The air or oxygen and electrolyte mist enter the reclaiming unit 58 at the inlets 60. The velocity of the electrolyte mist is reduced as it passes into the interior of the housing 64 though the flow diffusers 62.

The continuing entrance of air or oxygen carrying the electrolyte mist into the housing 64 forces the

mixture into the carbon fiber sponge 70, as shown by the directional flow arrows B and C in Figure 3. The electrolyte mist is removed from the carrying air or oxygen and collects on the carbon fiber sponge 70. The air or oxygen, after it passes through the sponge 70, enters the chamber 76 with a substantial percentage of the electrolyte effluent having been removed. Once in the chamber 76, the air or oxygen can exit the housing 64 at the exit 68.

As the electrolyte that is collected by the carbon fiber sponge 70 increases, a wicking process takes place according to which the excess electrolyte is absorbed by the carbon fiber wicks 72 which transport the electrolyte back to the electrolyte distribution system 42 as shown in Figure 2.

An alternate embodiment of the invention is shown in Figure 4. In this embodiment, the electrolyte that is collected by the carbon fiber sponge 70 is transported by the carbon fiber wicks 72 back to the electrolyte reservoir 46 for storage until it is needed.

In Figure 5, yet another alternate embodiment of the invention is shown. In this embodiment the reactant, hydrogen, and electrolyte mist are transported to an electrolyte reclamation unit 58 where the electrolyte is removed, collected, and transported to a storage unit 82. The hydrogen can then be recirculated or exited from the system.

It should be understood that the foregoing description is only illustrative of the invention. One obvious modification to the invention would be to provide a plurality of electrolyte collecting units in a series or parallel arrangement. Yet another obvious modification would be to provide a plurality of carbon fiber sponges and exits within one electrolyte collecting unit. Still another obvious modification of the invention would be to recirculate the exiting reactant

through the electrolyte collecting unit a plurality of times for a more efficient removal of the electrolyte. Other obvious alternatives of the invention would be to provide an electrolyte reclamation system for each cell in the stack or section of cells in the stack.

All of the foregoing patents and patent applications are incorporated herein by reference. Various alternatives and modifications in the structural and functional features of the invention can be devised by those skilled in the art without departing from the invention. Accordingly, the present invention is intended to embrace all such alternatives, modifications and variations and still fall within the spirit and scope of the appended claims.

CLAIMS

1. In the operation of a fuel cell having an electrolyte replenishing conduit extending between a reservoir and a matrix assembly, and having for each of the reactants an inlet chamber at an inlet end for delivery of the reactant to the fuel cell and an outlet chamber at an outlet end for withdrawal of the reactant from the fuel cell, the method of reclaiming the electrolyte and of purifying the reactant before subsequent use or release to the atmosphere comprising the steps of:

pumping the reactant from the inlet chamber to the outlet chamber such that the reactant assimilates quantities of the electrolyte present in the fuel cell in the form of a mist during operation of the fuel cell to thereby create at the outlet chamber a mixture composed of the reactant and the electrolyte mist;

transporting the mixture to a location external of the fuel cell;

removing the electrolyte from the reactant by coalescing the mist upon a fibrous sponge at the external location thereby purifying the reactant; and

returning the reclaimed electrolyte to the reservoir.

2. The method as set forth in Claim 1 wherein the step of removing the electrolyte includes the step of:

directing flow of the mixture across the fiber sponge capable of capturing the electrolyte while allowing continued passage therethrough of the reactant.

3. The method as set forth in Claim 1 including, intermediate the steps of transporting and removing, the steps of:

substantially reducing the velocity of the mixture after exiting the fuel cell; diffusing the mixture; and

directing flow of the diffused mixture across a fiber sponge capable of capturing the electrolyte and causing it to coalesce into droplet form while permitting continued passage therethrough of the reactant.

4. The method as set forth in Claim 3 including the step of drawing off from the fiber sponge the liquid electrolyte immediately prior to the step of returning the reclaimed electrolyte to the reservoir.

5. In a fuel cell having an electrolyte replenishing conduit extending between a reservoir and a matrix assembly, and having for each of the reactants an inlet chamber at an inlet end for delivery of the reactant to the fuel cell and an outlet chamber at an outlet end for withdrawal of the reactant from the fuel cell, apparatus for reclaiming the electrolyte and for purifying the reactant before subsequent use or release to the atmosphere comprising:

means for pumping the reactant from the inlet chamber to the outlet chamber such that the reactant assimilates quantities of the electrolyte present in the fuel cell in the form of a mist during operation of the fuel cell to thereby create at the outlet chamber a mixture composed of the reactant and the electrolyte mist;

electrolyte collecting means external of said fuel cell for reclaiming the electrolyte from the mixture;

conduit means for directing the mixture to said removal means; and

electrolyte removal means for removing electrolyte reclaimed by said collecting means and returning it to said reservoir.

6. A fuel cell as set forth in Claim 5 wherein said electrolyte collecting means includes:

an enclosed housing in communication with said conduit means and having an exit for the reactant and defining an interior volume which is much greater than that of said conduit means, thereby substantially reducing the velocity of the mixture as it travels from said conduit means into said housing; and

a carbon fiber sponge within said housing positioned in the path of flow of the mixture between said conduit means and said exit;

said carbon fiber sponge being capable of capturing the electrolyte mist and causing it to coalesce into droplet form while permitting continued passage therethrough of the reactant.

7. A fuel cell as set forth in Claim 6 wherein said collecting means includes a diffuser at the interface between said conduit means and said housing for diffusing the mixture as it enters said housing.

8. Apparatus as set forth in Claim 6 wherein the interior of said housing between said conduit means and said carbon fiber sponge is sealed to the atmosphere.

9. Apparatus as set forth in Claim 6 wherein said carbon fiber sponge defines an internal cavity communicating with said exit, the path of flow of the mixture being in the direction of the cavity.

10. Apparatus as set forth in Claim 6 wherein said carbon fiber sponge is generally in the form of a cylinder coaxial with said exit and defining an internal cavity communicating with said exit.

11. Apparatus as set forth in Claim 6 wherein said removal means includes:

a return conduit extending between said carbon fiber sponge and said reservoir; and

carbon wick means within said return conduit for transporting the reclaimed electrolyte from said carbon fiber sponge to said reservoir.

12. Apparatus as set forth in Claim 6 including:

an electrolyte distribution column in communication with said matrix assembly; and

wherein said removal means includes:

a return conduit extending between said carbon fiber sponge and said electrolyte distribution column; and

carbon wick means within said return conduit for transporting the reclaimed electrolyte from said carbon fiber sponge to said distribution column.

13. In a fuel cell system comprising a plurality of fuel cells operatively joined in a stacked relationship, each of said fuel cells having an electrolyte replenishing conduit extending between a reservoir and a matrix assembly, and having for each of the reactants an inlet chamber at an inlet end for delivery of the reactant to the fuel cell and an outlet chamber at an outlet end for withdrawal of the reactant from the fuel cell, apparatus for reclaiming the electrolyte and for purifying the reactant before subsequent use or release to the atmosphere comprising:

means for pumping the reactant from the inlet chamber to the outlet chamber such that the reactant assimilates quantities of the electrolyte present in the fuel cell in the form of a mist during operation of the fuel cell to thereby create at the outlet chamber a mixture composed of the reactant and the electrolyte mist;

electrolyte collecting means external of said fuel cell for reclaiming the electrolyte from the mixture;

conduit means for directing the mixture to said removal means; and

electrolyte removal means for removing electrolyte reclaimed by said collecting means and returning it to said reservoir.

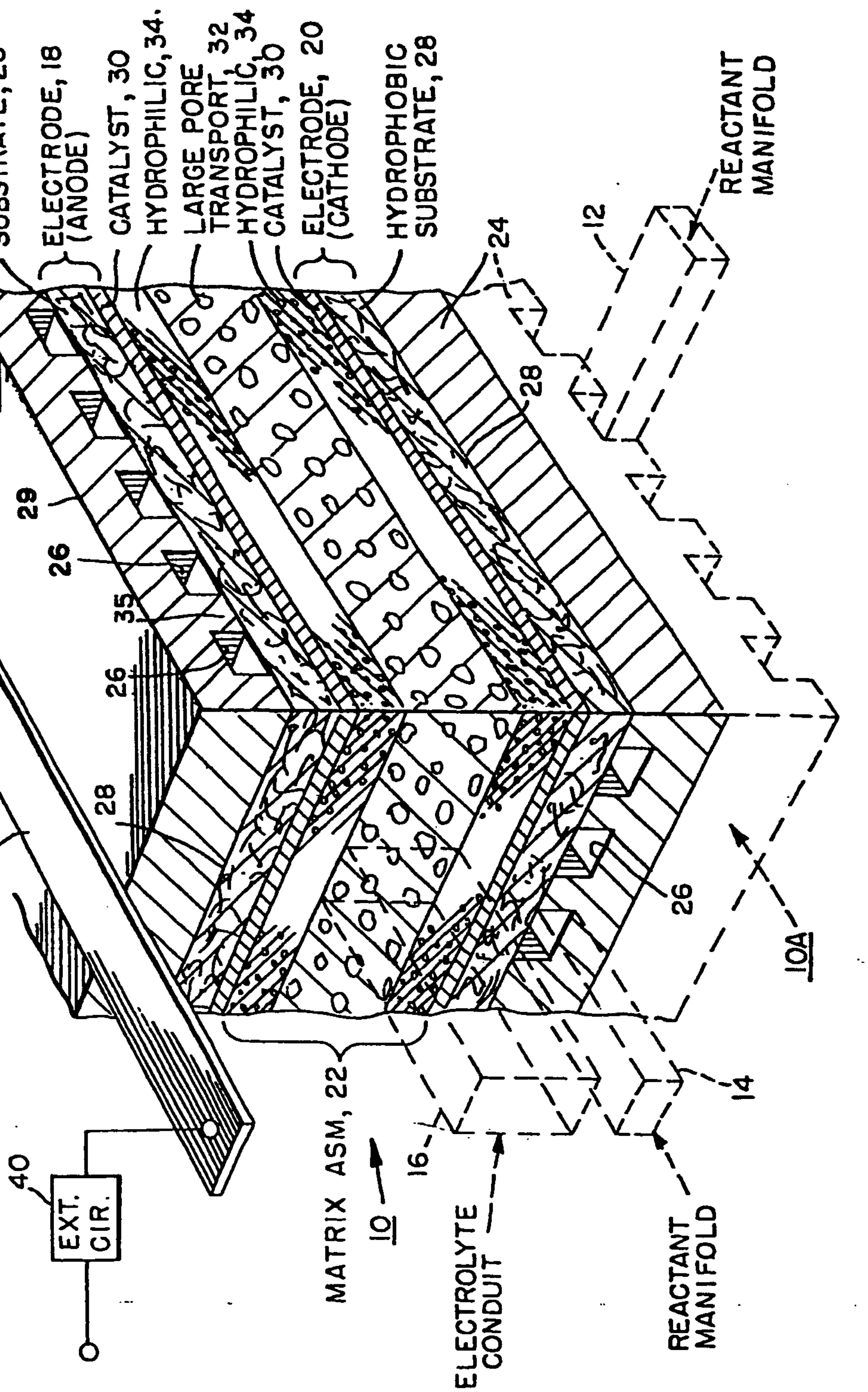
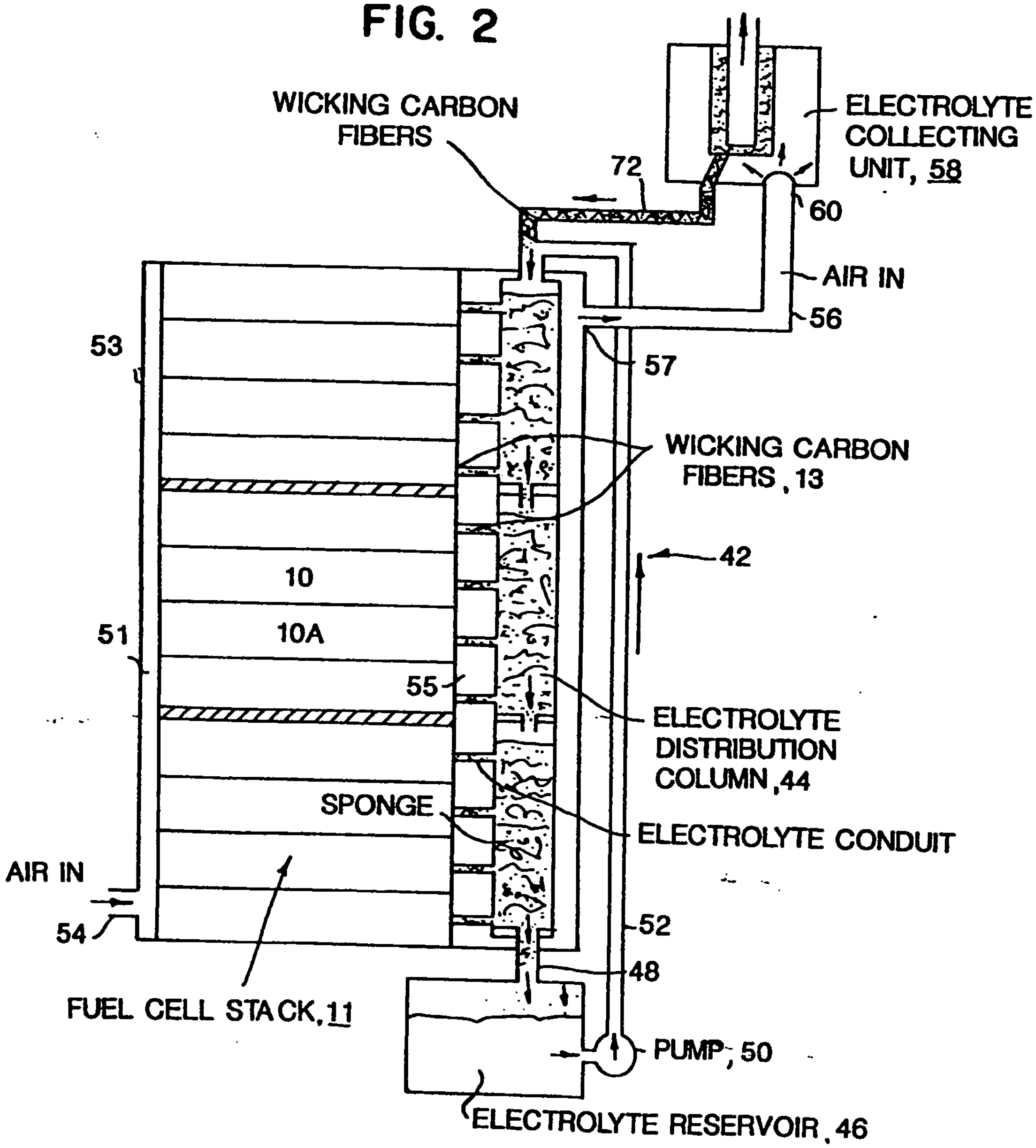

HYDROPHOBIC SUBSTRATE, 28
ELECTRODE, 18 (ANODE)
CATALYST, 30
HYDROPHILIC, 34.
LARGE PORE TRANSPORT, 32
HYDROPHILIC, 34
CATALYST, 30
ELECTRODE, 20 (CATHODE)
HYDROPHOBIC SUBSTRATE, 28
24
12
REACTANT MANIFOLD
28
29
26
35
26
28
38
26
10A
14
MATRIX ASM, 22
40
EXT. CIR.
10
16
ELECTROLYTE CONDUIT
REACTANT MANIFOLD

FIG. I

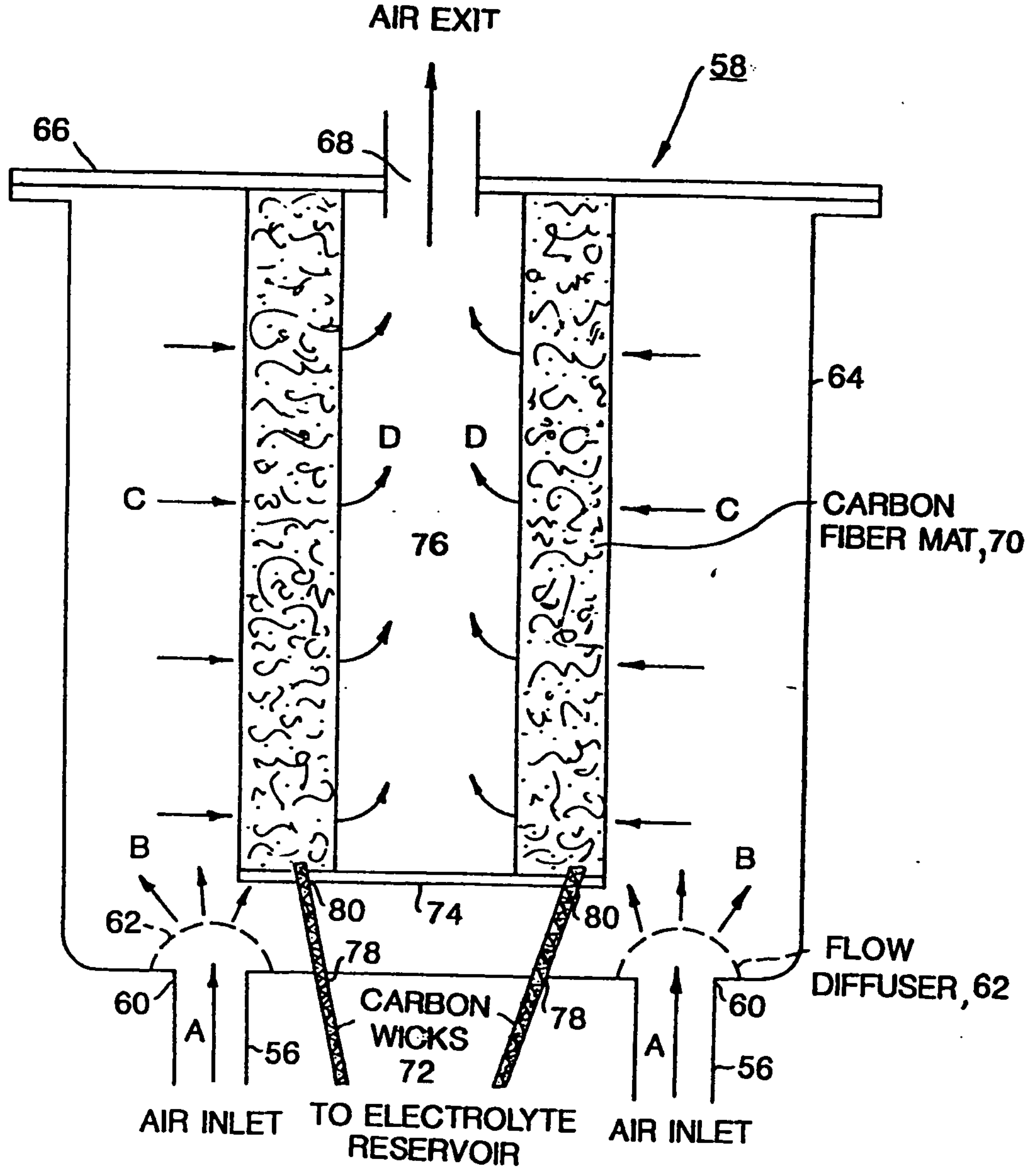
2/5

FIG. 2



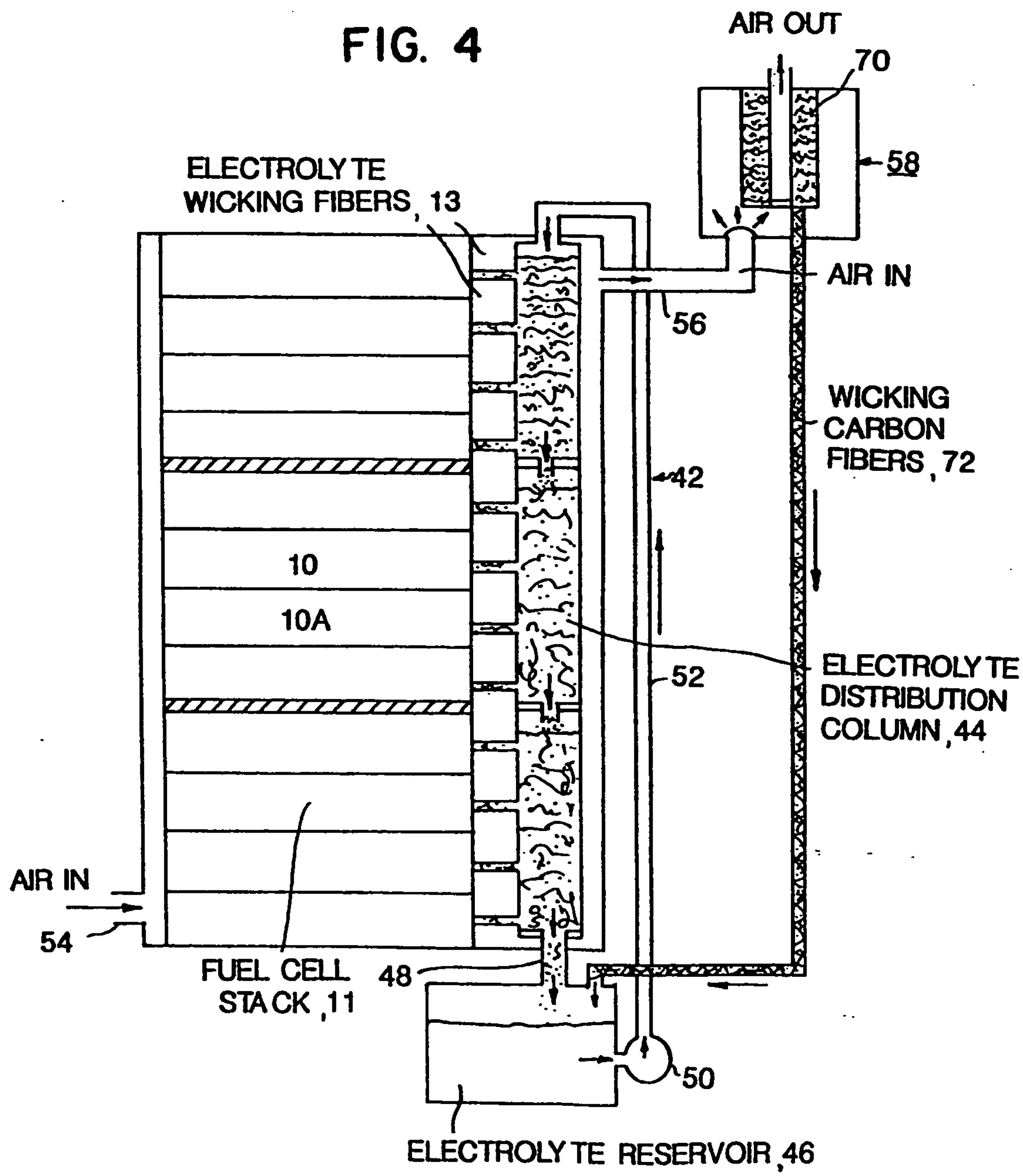
ELECTROLYTE MANAGEMENT SYSTEM WHICH INCORPORATES AN ELECTROLYTE RECYLCING UNIT. VERSION 1: ELECTROLYTE IS BEING RECYCLED TO TOP OF ELECTROLYTE DISTRIBUTION COLUMN.

FIG. 3



ELECTROLYTE MIST COLLECTOR

FIG. 4


AIR OUT
70
58
ELECTROLYTE WICKING FIBERS, 13
AIR IN
56
WICKING CARBON FIBERS, 72
42
10
10A
52
ELECTROLYTE DISTRIBUTION COLUMN, 44
AIR IN
54
FUEL CELL STACK, 11
48
50
ELECTROLYTE RESERVOIR, 46

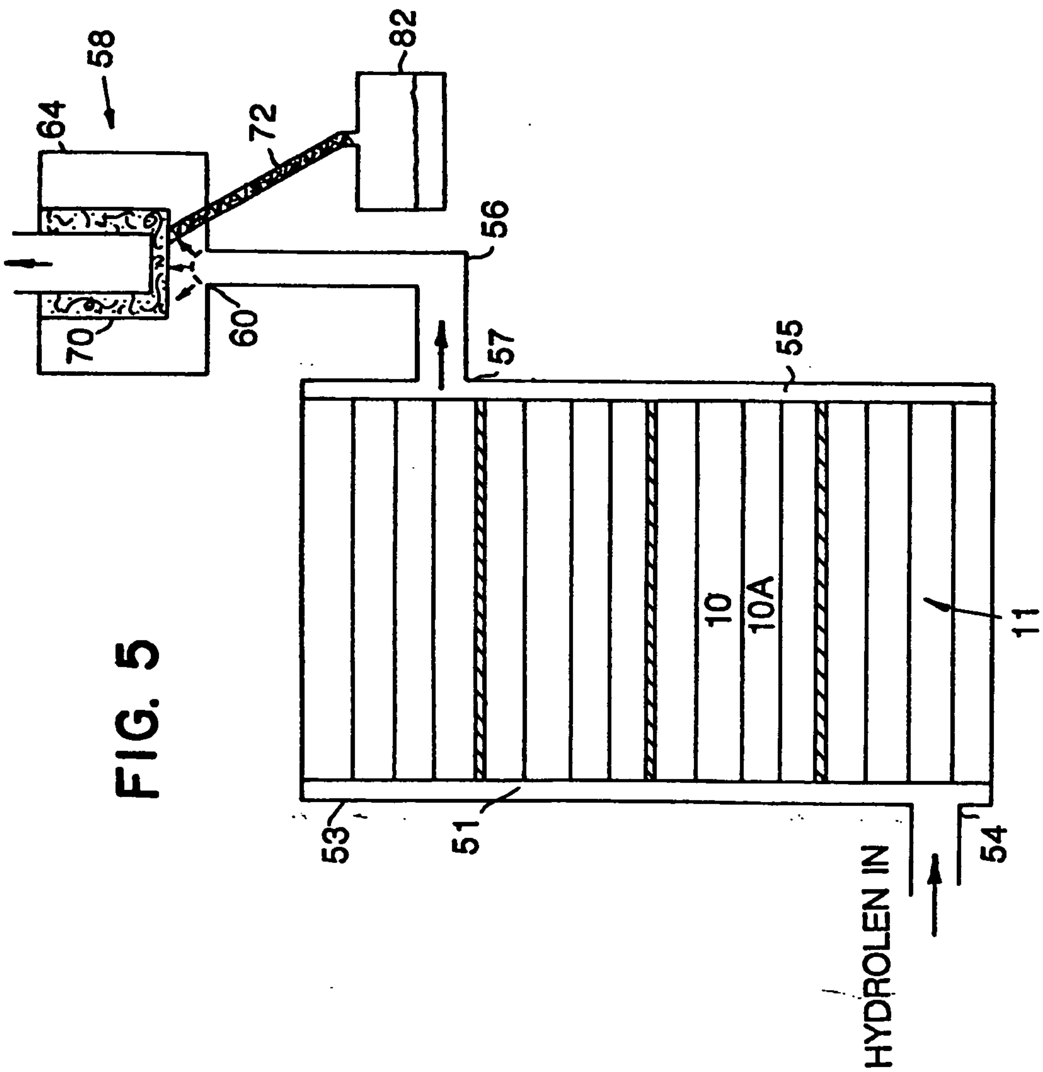


FIG. 5